

The stream fish fauna from the rio Machado basin, Rondônia State, Brazil

Lilian Casatti^{1*}, María Angélica Pérez-Mayorga¹, Fernando Rogério Carvalho¹, Gabriel Lourenço Brejão¹ and Igor David da Costa²

1 Universidade Estadual Paulista “Júlio de Mesquita Filho”, Departamento de Zoologia e Botânica, Laboratório de Ictiologia, Rua Cristóvão Colombo, 2265. CEP 15054-000. São José do Rio Preto, SP, Brazil.

2 Universidade Federal de Rondônia, Departamento de Engenharia de Pesca e Aquicultura, Rua da Paz, 4376. CEP 76916-000. Presidente Médici, RO, Brazil.

* Corresponding author: E-mail: licasatti@gmail.com

ABSTRACT: The rio Machado (also known as Ji-Paraná) is a tributary of the rio Madeira in the Amazon basin. Currently, the rio Madeira contains the greatest fish species richness of the world, with approximately 1,000 species. The present study presents the fish inventory from streams of the rio Machado basin. In total, 75 stream reaches, 80 meter-length, randomly selected, were sampled in 2011 (August to October) and 2012 (June to July). Overall, 22,875 fish in eight orders, 32 families, 89 genera, and 140 species were collected. Richness estimators indicate that almost 90% of the expected richness was registered. The great majority of specimens (52.2%) was represented by small sized piabas such as *Serrapinnus* aff. *notomelas*, *Moenkhausia collettii*, *Serrapinnus microdon*, and *Hemigrammus melanochrous*. Of the total richness, 25 species were restricted to 9°00' S and 10°00' S; among them, 14 were exclusive to the lower portion of the basin, which exhibits the larger proportion of native vegetation covering.

INTRODUCTION

In the Brazilian Amazon, the Rondônia State has been widely exposed to the effects resulting from deforestation. In 2001, 50.9% of the total area had been cleared; in 2004, this percentage increased to 57.1%; and in 2006, this percentage increased to 65.9% (INPE 2010). According to Dale *et al.* (1993), during 70's and 80's, the deforestation rate in the state of Rondônia has increased at a faster rate than anywhere else in the world. The highest level of deforestation occurs in the rio Machado basin, which drains the most populated area of the state because of its proximity to highway BR-364 (Fernandes and Guimarães 2002); within this basin, the central portion is the most deforested due to the occurrence of eutrophic soils (Krusche *et al.* 2005). Along the rio Machado basin, many upland streams have intermittent dry stretches in the dry season, and this situation has become more common recently because of the complete deforestation of many headwaters (Fernandes and Guimarães 2002).

Neotropical streams are very special ecosystems because they have many endemic species and are dominated by small-size species that generally correspond to approximately 50% of the known fish diversity (Castro *et al.* 2003). Proportional to the water volume available, streams are environments with high richness and, as noted by Castro and Menezes (1998) approximately 15 years ago, the study of systematics, evolution and the general biology of small fish species is undoubtedly the greatest challenge of Neotropical ichthyology. This knowledge starts with inventory studies, which are essential to manage and preserve an area or ecosystem due to the basic information provided. This type of study is even more urgent and necessary in situations in which there is a high threat of habitat loss, such as in the rio Machado

basin. Therefore, our aim was to present the results of an inventory conducted in the streams of the rio Machado basin, with a species estimation analysis and an analysis of the latitudinal species distribution.

MATERIALS AND METHODS

Study area and site selection

The rio Machado basin, formed by the confluence of the Comemoração and Pimenta Bueno rivers (Figure 1), has 75,400 km². The rio Machado is approximately 1,200 km long and receives five other tributaries (Rolim de Moura, Urupá, Jarú, Machadinho, and Preto rivers), flowing on the right bank of the rio Madeira (Krusche *et al.* 2005). Its flood regime, obtained from the data set for a five-year (2008-2012) period monthly average, is characterized by rising water between November and December, high water between January and March, with the highest water level in February; the falling water period is between April and July, the low water period between August and October with the minimum water level in September (ANA 2013). The basin has an average slope of 0.62 degrees. The climate is humid tropical, with temperatures from 19°C to 33°C and annual rainfall of 2,500 mm (Krusche *et al.* 2005). The land cover of the region includes primary forest (open humid tropical forest), secondary forest, and pasture (Ferraz *et al.* 2009).

The sampling design, local variable assessment, and fish collections were conducted during 2011 and 2012. The watershed limits were generated with the hydrological model ArcSWAT and digital elevation models (DEM) SRTM (90 x 90 m resolution) produced by the National Aeronautics and Space Administration (NASA) and are available from the United States Geological Survey (USGS). All the selected microbasins had a minimum contribution area between 1,500 and 5,000 ha.

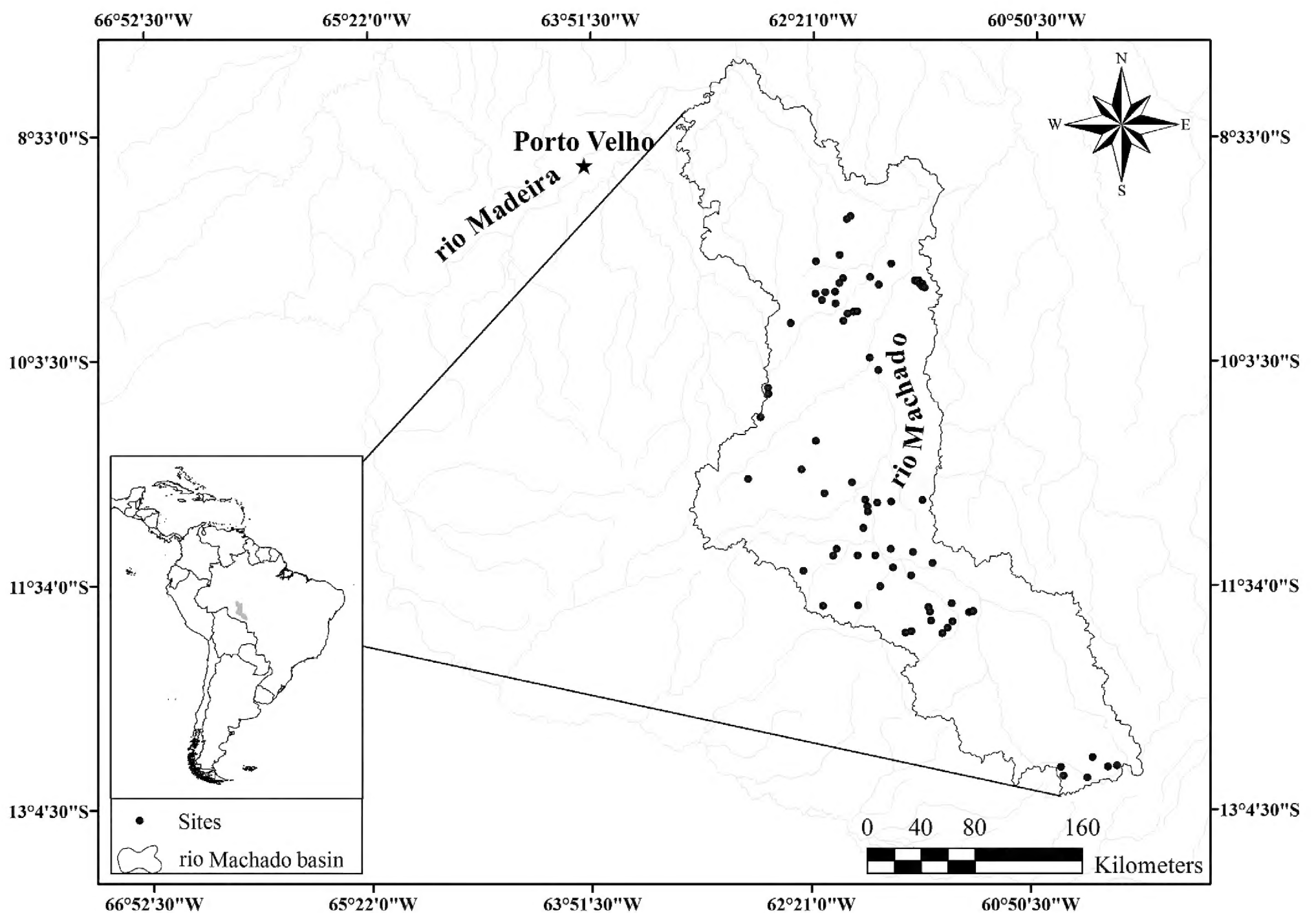


FIGURE 1. Location of the rio Machado basin in South America (small box on the left) and 75 sampling reaches in the rio Machado, Rondônia State, Brazil (black dots on the right). Some symbols are superimposed due to the proximity of sites.

Fish collection and identification

A total of 75 reaches (Table 1) were sampled once during the dry season (August to October, 2011 and June to July, 2012). Each headwater stream reach (1st to 3rd order reaches according to Sthraler 1957) was 80 m long and was sampled after blocking the reaches up- and downstream using block nets (5 mm mesh). During one hour, two collectors sampled fish with a seine (1.5 × 2 m, 2 mm mesh) and a dip net (0.5 × 0.8 m, 2 mm mesh). Fish were collected under ICMBio (Instituto Chico Mendes de Conservação da Biodiversidade) permits (4355-1/2012). The fish identification was conducted by consulting specialists, and voucher specimens are deposited in the Coleção de Peixes do Departamento de Zoologia e Botânica (DZSJRP) at the Universidade Estadual Paulista “Júlio de Mesquita Filho”, São José do Rio Preto, São Paulo State, Brazil (Table 2).

Data analysis

To evaluate the inventory representativeness, the Coleman rarefaction (Colwell *et al.* 2004) was obtained and compared to two non parametric richness estimators, the ICE (Incidence Coverage Estimator, Lee and Chao 1994) and the ACE (Abundance Coverage Estimator, Lee and Chao 1994), using the software EstimateS 7.5.2 (Cowell 2005). The latitudinal distribution of the fish fauna was evaluated by calculating the average and extreme values of latitude, considering all stream reaches in which each species occurs.

RESULTS AND DISCUSSION

A total of 22,875 specimens belonging to 140 species, 89 genera, 32 families, and eight orders were collected (Table 2). The Characiformes and Siluriformes, representing 51 and 31% of the total species, respectively, were predominant, which is consistent with the prevalence previously noted for the streams and rivers of the Neotropical region (Lowe-McConnell 1999). The families with the highest abundance in the sampled reaches were Characidae, Cichlidae, and Loricariidae, which are taxa that are broadly distributed in the Amazon basin (Reis *et al.* 2003). *Aequidens tetramerus*, *Bryconops caudomaculatus*, *Characidium* aff. *zebra*, *Creagrutus petilus*, *Crenicichla santosi*, *Moenkhausia oligolepis*, *M. collettii*, *Phenacogaster retropinnus*, and *Rineloricaria heteroptera* were broadly distributed in the rio Machado basin; they were recorded in more than 50% of the reaches. In contrast, 26 species (18.6%) occurred only in one site; most of them were recorded from the lower portion of the basin. Non-native species were represented by two specimens of *Tilapia rendalli*, and currently, the non-native threats appear to be of minor concern in the rio Machado basin. However, because of the recent development of aquaculture in the basin (author's observation), it is critical that appropriate precautions are taken so that non-native species do not become a threat to the local fish fauna.

The largest percentage of the fish abundance (52.2%) was represented by small-sized “piabas” of the family Characidae, such as *Serrapinnus* aff.

notomelas, *Moenkhausia collettii*, *Serrapinnus microdon*, *Hemigrammus melanochrous*, *Hyphessobrycon agulha*, *Creagrutus petilus*, and *Bryconops caudomaculatus*, in this order. The predominance of small fish species is in agreement with the overall pattern for South American stream fish and was explained by Castro (1999) as a result of selective pressures of the lotic environment in addition to the combination of geological history of South American basins, vicariant processes and allopatric speciation. Another common pattern is the great number of rare species. Of the total richness, 53 species (37.9%) were represented by less than ten specimens, and 14 species (10%) were represented by a single specimen, such as *Corydoras bondi* and *Miuroglanis platycephalus*, which indeed are species represented in fish collections by only a few records (≤ 10) (*SpeciesLink* 2013).

The richness estimated with ACE and ICE was 148 and 157 species, respectively, which indicates that more than

90% of the estimated species richness was registered and shows good representativeness of the inventory (Figure 2). Inventories of ichthyofauna for the western Amazon region are scarce. Among those that have been conducted in the rio Madeira basin, we highlight the study by Perin *et al.* (2007), which recorded 48 fish species in an urban area of Rondônia; the study by Camargo and Giarrizzo (2007), which recorded 133 species in 23 streams and three rivers of the Marmelos Preservation Area; and the study by Barros *et al.* (2011), which recorded 78 species in 22 streams in the Madeira-Purus interfluvial region. Despite the different sampling methodologies employed among these studies, they clearly demonstrate the great fish diversity in the rio Madeira basin, with a high percentage of species yet to be found and described.

Of the total species collected, 97 (69.3%) were identified to species level, 43 (30.7%) are of uncertain taxonomic status, because they are not formally described (16 species)

FIGURE 1. Municipality, altitude (m), and geographical coordinates of the 75 stream reaches sampled in the rio Machado basin. Sites 24 to 31 are located in the Reserva Biológica (REBio) Jaru, 33 to 35 in the Reserva Extrativista (RESEX) Rio Preto-Jacundá, 38 and 39 in the RESEX Castanheira, and 43 to 45 in the RESEX Aquariquara.

SITES	MUNICIPALITY	ELEVATION	GEOGRAPHICAL COORDINATES	SITES	MUNICIPALITY	ELEVATION	GEOGRAPHICAL COORDINATES
1	Presidente Médici	196.64	62°00'21"W, 11°12'06"S	40	Ariquemes	198.49	62°39'13"W, 10°15'28"S
2	Alvorada d'Oeste	251.97	62°24'55"W, 11°29'31"S	41	Theobroma	202.45	62°38'40"W, 10°18'12"S
3	Teixerópolis	193.24	62°16'18"W, 10°58'06"S	42	Jaru	199.19	62°42'33"W, 10°27'24"S
4	Ji-Paraná	183.93	62°05'03"W, 10°53'45"S	43	Vale do Anari	182.46	62°07'01"W, 09°45'33"S
5	Nova União	198.81	62°47'28"W, 10°52'20"S	44	Vale do Anari	199.70	62°05'58"W, 09°45'00"S
6	Nova União	199.44	62°25'38"W, 10°48'38"S	45	Vale do Anari	192.08	62°03'10"W, 09°44'35"S
7	Ouro Preto d'Oeste	226.68	62°19'56"W, 10°36'52"S	46	Vale do Anari	194.09	62°08'53"W, 09°48'24"S
8	Castanheiras	190.74	61°55'23"W, 11°23'15"S	47	Ministro Adreazza	298.80	61°36'15"W, 11°00'55"S
9	Nova Brasilândia d'Oeste	286.23	62°16'48"W, 11°43'38"S	48	Presidente Médici	210.56	61°50'10"W, 11°00'10"S
10	Rolim de Moura	236.09	62°02'26"W, 11°43'27"S	49	Nova Brasilândia d'Oeste	200.01	62°03'19"W, 11°21'51"S
11	Santa Luzia d'Oeste	254.74	61°40'24"W, 11°53'45"S	50	Presidente Médici	195.01	61°49'04"W, 11°20'14"S
12	Santa Luzia d'Oeste	248.89	61°42'53"W, 11°54'21"S	51	Cacoal	200.37	61°39'51"W, 11°21'59"S
13	Presidente Médici	180.28	61°54'42"W, 11°01'51"S	52	Ji-Paraná	188.47	61°59'34"W, 11°00'54"S
14	Cujubim	178.86	62°20'05"W, 09°24'21"S	53	Ji-Paraná	184.21	61°58'46"W, 11°03'27"S
15	Machadinho d'Oeste	184.77	62°10'22"W, 09°21'47"S	54	Ji-Paraná	185.33	61°58'39"W, 11°05'31"S
16	São Felix	143.06	61°49'19"W, 09°25'17"S	55	Alvorada d'Oeste	200.42	62°11'05"W, 11°20'23"S
17	Vale do Anari	174.88	62°12'09"W, 09°36'42"S	56	Alvorada d'Oeste	204.94	62°12'49"W, 11°23'24"S
18	Vale do Anari	198.53	62°16'08"W, 09°36'58"S	57	Cacoal	191.29	61°32'04"W, 11°25'47"S
19	Vale do Anari	192.34	62°20'13"W, 09°37'28"S	58	Cacoal	198.01	61°40'41"W, 11°31'09"S
20	Vale do Anari	182.19	62°17'29"W, 09°40'06"S	59	Castanheiras	198.10	61°47'50"W, 11°28'10"S
21	Vale do Anari	175.20	62°30'11"W, 09°49'26"S	60	Castanheiras	201.51	61°52'20"W, 11°35'36"S
22	Vale do Anari	119.48	61°58'09"W, 10°04'14"S	61	Vilhena	333.78	60°27'46"W, 12°52'24"S
23	Theobroma	119.48	61°54'32"W, 10°08'35"S	62	Vilhena	518.15	60°18'50"W, 12°47'36"S
24	Vale do Anari	103.87	61°39'15"W, 09°32'10"S	63	Vilhena	565.15	60°15'12"W, 12°47'48"S
25	Vale do Anari	151.50	61°38'53"W, 09°32'37"S	64	Vilhena	507.51	60°24'33"W, 12°47'08"S
26	Vale do Anari	126.54	61°38'40"W, 09°32'31"S	65	Chupinguaia	375.68	60°39'14"W, 12°48'39"S
27	Vale do Anari	107.91	61°37'42"W, 09°32'54"S	66	Chupinguaia	410.26	60°37'58"W, 12°51'05"S
28	Vale do Anari	103.91	61°36'39"W, 09°33'25"S	67	Primavera de Rondônia	201.15	61°16'29"W, 11°45'45"S
29	Vale do Anari	126.98	61°36'50"W, 09°34'20"S	68	Primavera de Rondônia	206.21	61°15'55"W, 11°46'20"S
30	Vale do Anari	115.46	61°36'26"W, 09°34'43"S	69	Primavera de Rondônia	210.23	61°23'19"W, 11°44'04"S
31	Vale do Anari	155.00	61°36'17"W, 09°35'42"S	70	São Felipe d'Oeste	236.71	61°24'10"W, 11°49'53"S
32	Machadinho d'Oeste	192.98	62°09'44"W, 09°40'03"S	71	Rolim de Moura	296.40	61°33'41"W, 11°50'17"S
33	Machadinho d'Oeste	189.14	62°05'55"W, 09°06'15"S	72	Rolim de Moura	222.27	61°32'55"W, 11°45'47"S
34	Machadinho d'Oeste	163.65	62°07'28"W, 09°07'17"S	73	Rolim de Moura	213.46	61°32'50"W, 11°44'44"S
35	Machadinho d'Oeste	158.76	62°07'33"W, 09°07'20"S	74	São Felipe d'Oeste	288.21	61°28'07"W, 11°56'08"S
36	Machadinho d'Oeste	129.13	61°57'55"W, 09°30'52"S	75	São Felipe d'Oeste	258.46	61°25'36"W, 11°52'13"S
37	Machadinho d'Oeste	218.32	61°55'45"W, 09°33'19"S				
38	Machadinho d'Oeste	186.78	62°10'30"W, 09°33'15"S				
39	Machadinho d'Oeste	188.66	62°08'49"W, 09°31'21"S				

or belong to genera that need more detailed review (27 species), such as *Brachyhypopomus*, *Cetopsorhamdia*, and *Moenkhausia*. The percentage of species with uncertain taxonomic situations is high compared with the South and Southeast regions of Brazil, but it is small when compared to other Amazonian ecoregions. Advances in the knowledge on the fish fauna from the rio Madeira basin result from recent inventories that were led by the ichthyology team at the Federal University of Rondônia (UNIR). The rio Madeira basin, among all tributaries of the Amazon basin and even when compared with another rivers in the world, has the richest freshwater fish fauna of the world, in which approximately 1,000 freshwater fish species have been recognized (W. Ohara, pers. comm.). However, in Rondônia State, accelerated deforestation is the main source of degradation to the streams, making it urgent to acquire the taxonomic, geographical, and ecological knowledge of the ichthyofauna in these environments. As a potential additional threat to this fish fauna we can cite the expansion of hydroelectric power plants.

According to the species latitudinal distribution analysis, 25 species (18%) only occur between 9°00’S and 10°00’S (Figure 3); among them, nine were exclusively registered in streams reaches inside protected areas (REBio Jaru, RESEX Rio Preto-Jacundá, RESEX Castanheira, and RESEX Aquariquara). Extractive reserves of Rondônia, such as the RESEX Rio Preto-Jacundá, have adopted forest

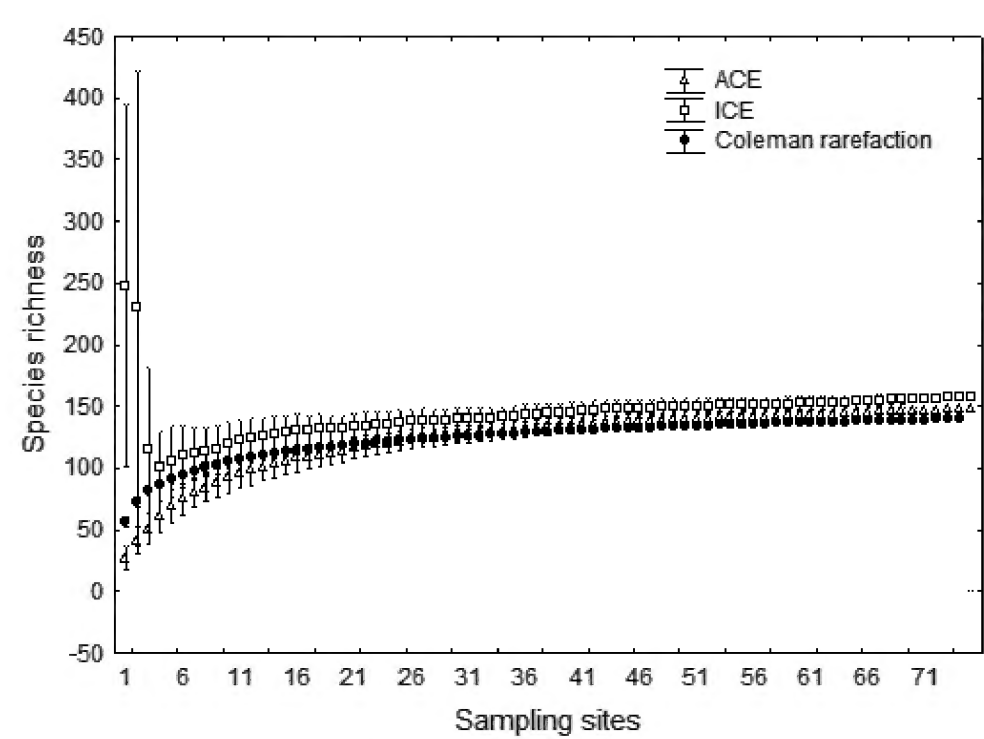


FIGURE 2. Coleman rarefaction curve, showing the observed richness, and curves of estimated number of species derived from ICE (Incidence Coverage Estimator) and ACE (Abundance Coverage Estimator) by 50 randomizations against cumulative samples.

management as an activity that is capable of generating a better quality of life for the extractive region while preserving the forest. However, as described by Martins (2008) and Moreira *et al.* (2010), the current forest management is not able to secure these goals, which represents a potential threat to the conservation of the regional species pool, endangering one of the world’s most diverse ichthyofauna.

TABLE 2. Fish species sampled in headwater streams of the rio Machado basin, with their abundance (N) and the catalogue number of the voucher specimens. Classification follows Reis *et al.* (2003); except for Serrasalminae that follows Calcagnotto *et al.* (2005) and *Parauchenipterus porosus* that follows Buckup *et al.* (2007). Single quotation marks indicate provisional genera and asterisk indicate non-native species.

TAXON	N	VOUCHER
MYLIOBATIFORMES		
Potamotrygonidae		
<i>Potamotrygon orbignyi</i> (Castelnau, 1855)	1	DZSJRP 17112
CHARACIFORMES		
Parodontidae		
<i>Parodon nasus</i> Kner, 1859	4	DZSJRP 14506
Curimatidae		
<i>Curimatopsis macrolepis</i> (Steindachner, 1876)	6	DZSJRP 16692
<i>Cyphocharax plumbeus</i> (Eigenmann and Eigenmann, 1889)	1	DZSJRP 17238
<i>Cyphocharax spiluropsis</i> (Eigenmann and Eigenmann, 1889)	40	DZSJRP 16630
<i>Steindachnerina cf. dobula</i> (Günther, 1868)	4	DZSJRP 14512
<i>Steindachnerina fasciata</i> (Vari and Géry, 1985)	57	DZSJRP 14661
<i>Steindachnerina guentheri</i> (Eigenmann and Eigenmann, 1889)	3	DZSJRP 16782
Prochilodontidae		
<i>Prochilodus nigricans</i> Spix and Agassiz, 1829	1	DZSJRP 16799
Anostomidae		
<i>Anostomus ternetzi</i> Fernández-Yépez, 1949	5	DZSJRP 14664
<i>Leporinus friderici</i> (Block, 1794)	36	DZSJRP 14763
Crenuchidae		
<i>Characidium</i> aff. <i>gomesi</i> Travassos, 1956	7	DZSJRP 14704
<i>Characidium</i> aff. <i>zebra</i> Eigenmann, 1909	762	DZSJRP 14703
<i>Characidium</i> sp.	8	DZSJRP 14335
<i>Elachocharax pulcher</i> Myers, 1927	79	DZSJRP 15057
<i>Microcharacidium</i> sp.	50	DZSJRP 16653
<i>Microcharacidium</i> aff. <i>weitzmani</i> Buckup, 1996	38	DZSJRP 14986
<i>Melanocharacidium dispilomma</i> Buckup, 1993	1	DZSJRP 17205
<i>Melanocharacidium pectorale</i> Buckup, 1993	1	DZSJRP 16678
Hemiodontidae		
<i>Hemiodus unimaculatus</i> (Block, 1794)	2	DZSJRP 14672
Gasteropelecidae		

TABLE 2. CONTINUED.

TAXON	N	VOUCHER
<i>Carnegiella strigata</i> (Günther, 1864)	40	DZSJRP 14886
Characidae		
<i>Amazonspinther dalmata</i> Bührnheim, Carvalho, Malabarba and Weitzman, 2008	7	DZSJRP 14947
<i>Astyanax</i> cf. <i>bimaculatus</i> (Linnaeus, 1758)	108	DZSJRP 14419
<i>Astyanax</i> cf. <i>maximus</i> (Steindachner, 1876)	18	DZSJRP 14460
<i>Astyanax maculisquamis</i> Garutti and Britski, 1997	43	DZSJRP 14700
<i>Bario steindachneri</i> (Eigenmann, 1893)	3	DZSJRP 15090
<i>Brachyhalcinus copei</i> (Steindachner, 1822)	147	DZSJRP 14769
<i>Bryconops caudomaculatus</i> (Günther, 1864)	912	DZSJRP 14628
<i>Bryconops piracolina</i> Wingert and Malabarba, 2011	23	DZSJRP 17278
<i>Bryconella pallidifrons</i> (Fowler, 1946)	695	DZSJRP 16651
' <i>Cheirodon</i> ' <i>troemneri</i> Fowler, 1942	62	DZSJRP 14668
<i>Creagrutus petilus</i> Vari and Harold, 2001	1021	DZSJRP 14733
<i>Hemigrammus</i> sp.	14	DZSJRP 15101
<i>Hemigrammus</i> aff. <i>ocellifer</i> (Steindachner, 1882)	62	DZSJRP 15009
<i>Hemigrammus bellotti</i> (Steindachner, 1882)	152	DZSJRP 14524
<i>Hemigrammus melanochrous</i> Fowler, 1913	1418	DZSJRP 15100
<i>Hemigrammus neptunus</i> Zarske and Géry, 2002	60	DZSJRP 14710
<i>Hyphessobrycon</i> aff. <i>heterorhabdus</i> (Ulrey, 1894)	144	DZSJRP 16929
<i>Hyphessobrycon agulha</i> Fowler, 1913	1131	DZSJRP 15103
<i>Hyphessobrycon bentosi</i> Durbin, 1908	178	DZSJRP 15011
<i>Hyphessobrycon copelandi</i> Durbin, 1908	151	DZSJRP 14673
<i>Jupiaba citrina</i> Zanata and Ohara, 2009	273	DZSJRP 14701
<i>Jupiaba poranga</i> Zanata, 1997	9	DZSJRP 15107
<i>Jupiaba zonata</i> (Eigenmann, 1908)	55	DZSJRP 19916
<i>Knodus</i> cf. <i>smithi</i> Fowler, 1913	827	DZSJRP 14715
<i>Knodus heteresthes</i> Eigenmann, 1908	736	DZSJRP 14651
<i>Microchemobrycon guaporensis</i> Eigenmann, 1915	166	DZSJRP 14476
<i>Moenkhausia</i> aff. <i>gracilima</i> Eigenmann, 1908	1	DZSJRP 16817
<i>Moenkhausia</i> cf. <i>bonita</i> Benine, Castro and Sabino, 2004	339	DZSJRP 14717
<i>Moenkhausia</i> cf. <i>justae</i> Eigenmann, 1908	41	DZSJRP 14526
<i>Moenkhausia collettii</i> (Steindachner, 1882)	1924	DZSJRP 14639
<i>Moenkhausia cotinho</i> Eigenmann, 1908	259	DZSJRP 14478
<i>Moenkhausia grandisquamis</i> Müller and Troschel, 1845	11	DZSJRP 14962
<i>Moenkhausia mikia</i> Marinho and Langeani, 2010	105	DZSJRP 14447
<i>Moenkhausia oligolepis</i> (Günther, 1864)	330	DZSJRP 14479
<i>Moenkhausia pirauba</i> Zanata, Birindelli and Moreira, 2010	19	DZSJRP 15112
<i>Odontostilbe fugitiva</i> Cope, 1870	307	DZSJRP 14545
<i>Phenacogaster retropinnus</i> Lucena and Malabarba, 2010	386	DZSJRP 14450
<i>Serrapinnus</i> aff. <i>notomelas</i> (Eigenmann, 1915)	3642	DZSJRP 14659
<i>Serrapinnus microdon</i> (Eigenmann, 1915)	1901	DZSJRP 14658
<i>Tetragonopterus argenteus</i> Cuvier, 1816	2	DZSJRP 17040
<i>Triportheus angulatus</i> (Spix and Agassiz, 1829)	2	DZSJRP 14456
<i>Tyttocharax madeirae</i> Fowler, 1913	32	DZSJRP 14945
Serrasalminidae		
<i>Myleus</i> sp.	12	DZSJRP 14741
<i>Serrasalmus rhombeus</i> (Linnaeus, 1766)	1	DZSJRP 14695
Acestrorhynchidae		
<i>Acestrorhynchus falcatus</i> (Bloch, 1794)	3	DZSJRP 17072
Erythrinidae		
<i>Erythrinus erythrinus</i> (Bloch and Schneider, 1801)	11	DZSJRP 16650
<i>Hoplerythrinus unitaeniatus</i> (Spix and Agassiz, 1829)	3	DZSJRP 16764
<i>Hoplias malabaricus</i> (Bloch, 1794)	88	DZSJRP 14538
Lebiasinidae		
<i>Nannostomus trifasciatus</i> Steindachner, 1876	1	DZSJRP 14963
<i>Pyrhulina</i> cf. <i>australis</i> Eigenmann and Kennedy, 1903	193	DZSJRP 14634
<i>Pyrhulina</i> cf. <i>brevis</i> Steindachner, 1876	65	DZSJRP 15115
<i>Pyrhulina</i> cf. <i>zigzag</i> Zarske and Géry, 1997	9	DZSJRP 17280
SILURIFORMES		
Cetopsidae		
<i>Denticetopsis seducta</i> (Vari, Ferraris and de Pinna, 2005)	4	DZSJRP 14887
<i>Helogenes gouldingi</i> Vari and Ortega, 1986	22	DZSJRP 15099

TABLE 2. CONTINUED.

TAXON	N	VOUCHER
Aspredinidae		
<i>Pseudobunocephalus amazonicus</i> (Mees, 1989)	37	DZSJRP 14940
Trichomycteridae		
<i>Ituglanis amazonicus</i> (Steindachner, 1882)	108	DZSJRP 14676
<i>Miuroglanis platycephalus</i> Eigenmann and Eigenmann, 1889	1	DZSJRP 14963
<i>Paracanthopoma</i> sp.	19	DZSJRP 14905
Callichthyidae		
<i>Corydoras acutus</i> Cope, 1872	5	DZSJRP 15023
<i>Corydoras</i> aff. <i>ambiacus</i> Cope, 1872	3	DZSJRP 17229
<i>Corydoras</i> cf. <i>melanistius</i> Regan, 1912	55	DZSJRP 15124
<i>Corydoras bondi</i> Gosline, 1940	1	DZSJRP 17263
<i>Corydoras elegans</i> Steindachner, 1876	7	DZSJRP 14422
<i>Corydoras stenocephalus</i> Eigenmann and Allen, 1942	5	DZSJRP 16757
<i>Corydoras trilineatus</i> Cope, 1872	82	DZSJRP 14755
<i>Hoplosternum littorale</i> (Hancock, 1828)	7	DZSJRP 14423
<i>Megalechis picta</i> (Müller and Troschel, 1849)	49	DZSJRP 16753
Loricariidae		
<i>Ancistrus lithurgicus</i> Eigenmann, 1912	290	DZSJRP 14418
<i>Farlowella</i> cf. <i>oxyrryncha</i> (Kner, 1853)	120	DZSJRP 14671
<i>Squaliforma emarginata</i> (Valenciennes, 1840)	22	DZSJRP 14712
<i>Hypostomus</i> sp.	1	DZSJRP 17290
<i>Hypostomus pyrineusi</i> (Miranda Ribeiro, 1920)	34	DZSJRP 14424
<i>Lasiancistrus schomburgkii</i> (Günther, 1864)	61	DZSJRP 14697
<i>Loricaria cataphracta</i> Linnaeus, 1758	4	DZSJRP 14499
<i>Otocinclus hoppei</i> Miranda Ribeiro, 1939	119	DZSJRP 14685
<i>Parotocinclus</i> aff. <i>aripuanensis</i> Garavello, 1988	24	DZSJRP 14895
<i>Rineloricaria</i> sp.	6	DZSJRP 14635
<i>Rineloricaria heteroptera</i> Isbrücker and Nijssen, 1976	164	DZSJRP 14427
<i>Spatuloricaria evansii</i> (Boulenger, 1892)	4	DZSJRP 14511
Pseudopimelodidae		
<i>Batrochoglanis</i> cf. <i>raninus</i> (Valenciennes, 1840)	16	DZSJRP 14969
<i>Batrochoglanis villosus</i> (Eigenmann, 1912)	5	DZSJRP 14665
<i>Microglanis poecilus</i> Eigenmann, 1912	1	DZSJRP 16655
Heptapteridae		
<i>Cetopsorhamdia</i> sp. 1	24	DZSJRP 17295
<i>Cetopsorhamdia</i> sp. 2	8	DZSJRP 17279
<i>Cetopsorhamdia</i> sp. 3	6	DZSJRP 17216
<i>Imparfinis</i> cf. <i>hasemani</i> Steindachner, 1917	124	DZSJRP 14714
<i>Imparfinis stictonotus</i> (Fowler, 1940)	49	DZSJRP 14471
<i>Phenacorhamdia</i> cf. <i>boliviana</i> (Pearson, 1924)	4	DZSJRP 14688
<i>Phenacorhamdia</i> sp.	70	DZSJRP 15019
<i>Pimelodella</i> sp.	11	DZSJRP 14527
<i>Pimelodella</i> cf. <i>howesi</i> Fowler, 1940	55	DZSJRP 14656
<i>Rhamdia quelen</i> (Quoy and Gaimard, 1824)	6	DZSJRP 14770
Doradidae		
<i>Acanthodoras cataphractus</i> (Linnaeus, 1758)	19	DZSJRP 16687
Auchenipteridae		
<i>Centromochlus</i> cf. <i>perugia</i> Steindachner, 1882	1	DZSJRP 17261
<i>Tatia aulopygia</i> (Kner, 1858)	2	DZSJRP 14696
<i>Parauchenipterus porosus</i> (Eigenmann and Eigenmann, 1888)	5	DZSJRP 17038
GYMNOTIFORMES		
Gymnotidae		
<i>Gymnotus</i> aff. <i>arapaima</i> Albert and Crampton, 2001	26	DZSJRP 14649
<i>Gymnotus carapo</i> Linnaeus, 1758	35	DZSJRP 14648
<i>Gymnotus coropinae</i> Hoederman, 1962	81	DZSJRP 15006
Sternopygidae		
<i>Eigenmannia trilineata</i> López and Castello, 1966	196	DZSJRP 14406
<i>Sternopygus macrurus</i> (Bloch and Schneider, 1801)	99	DZSJRP 14484
Rhamphichthyidae		
<i>Gymnorhamphichthys petiti</i> Géry and Vu-Tân-Tuê, 1964	287	DZSJRP 14631
Hypopomidae		
<i>Brachyhypopomus</i> sp. 1	2	DZSJRP 14627

TABLE 2. CONTINUED.

TAXON	N	VOUCHER
<i>Brachyhypopomus</i> sp. 2	15	DZSJRP 15091
<i>Brachyhypopomus</i> sp. 3	26	DZSJRP 15092
<i>Hypopygus lepturus</i> Hoedeman, 1962	128	DZSJRP 14632
Apteronotidae		
<i>Apteronotus albifrons</i> (Linnaeus, 1766)	6	DZSJRP 14641
<i>Platyurosternarchus macrostomus</i> (Günther, 1864)	2	DZSJRP 14690
CYPRINODONTIFORMES		
Rivulidae		
<i>Rivulus</i> sp.	4	DZSJRP 14942
BELONIFORMES		
Belonidae		
<i>Potamorrhaphis eigenmanni</i> Miranda Ribeiro, 1915	2	DZSJRP 14949
SYNBRANCHIFORMES		
Synbranchidae		
<i>Synbranchus marmoratus</i> Bloch, 1795	22	DZSJRP 14485
PERCIFORMES		
Cichlidae		
<i>Aequidens tetramerus</i> (Heckel, 1840)	199	DZSJRP 14626
<i>Apistogramma</i> cf. <i>resticulosa</i> Kullander, 1980	563	DZSJRP 14994
<i>Cichlasoma amazonarum</i> Kullander, 1983	46	DZSJRP 14462
<i>Crenicichla johanna</i> Heckel, 1840	2	DZSJRP 14758
<i>Crenicichla santosi</i> Ploeg, 1991	163	DZSJRP 14757
<i>Geophagus megasema</i> Heckel, 1840	1	DZSJRP 15004
<i>Satanoperca jurupari</i> (Heckel, 1840)	60	DZSJRP 14636
<i>Tilapia rendalli</i> (Boulenger, 1897) *	2	DZSJRP 14431
TOTAL	22875	

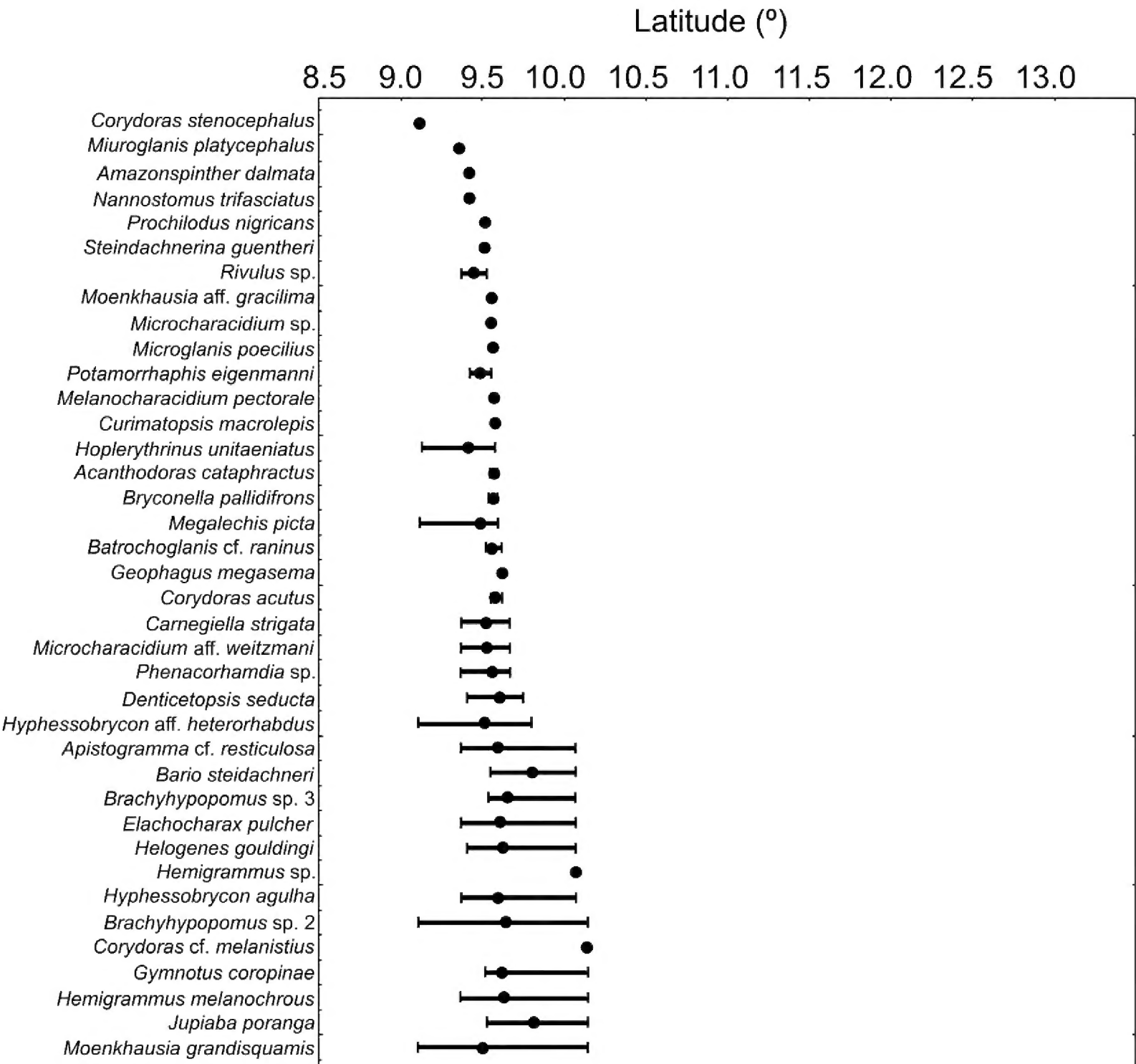


FIGURE 3. Latitudinal distribution of 140 species collected in the rio Machado basin. Bars indicate latitudinal range for each species, dots indicate average latitude.

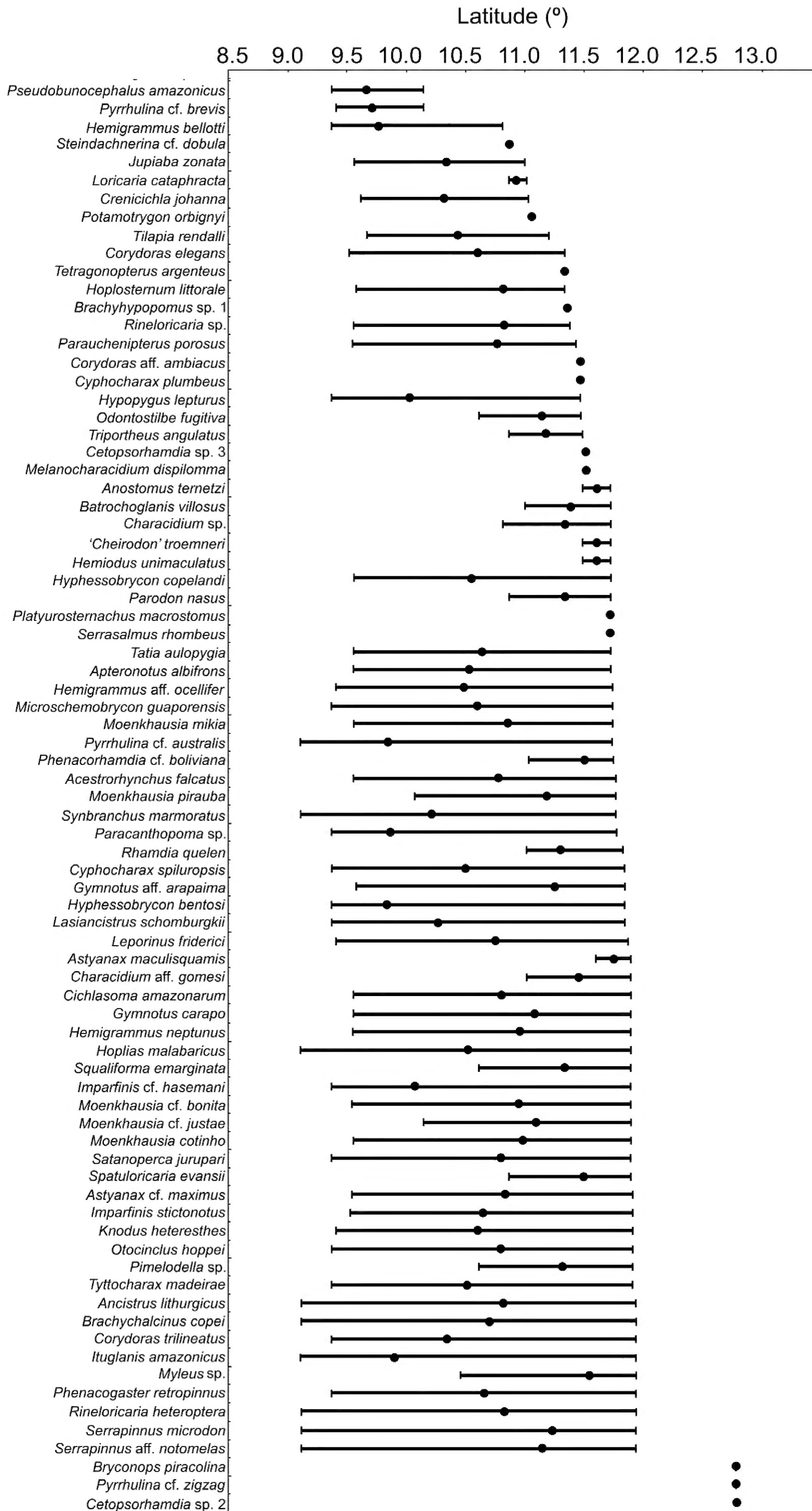


FIGURE 3. CONTINUED.

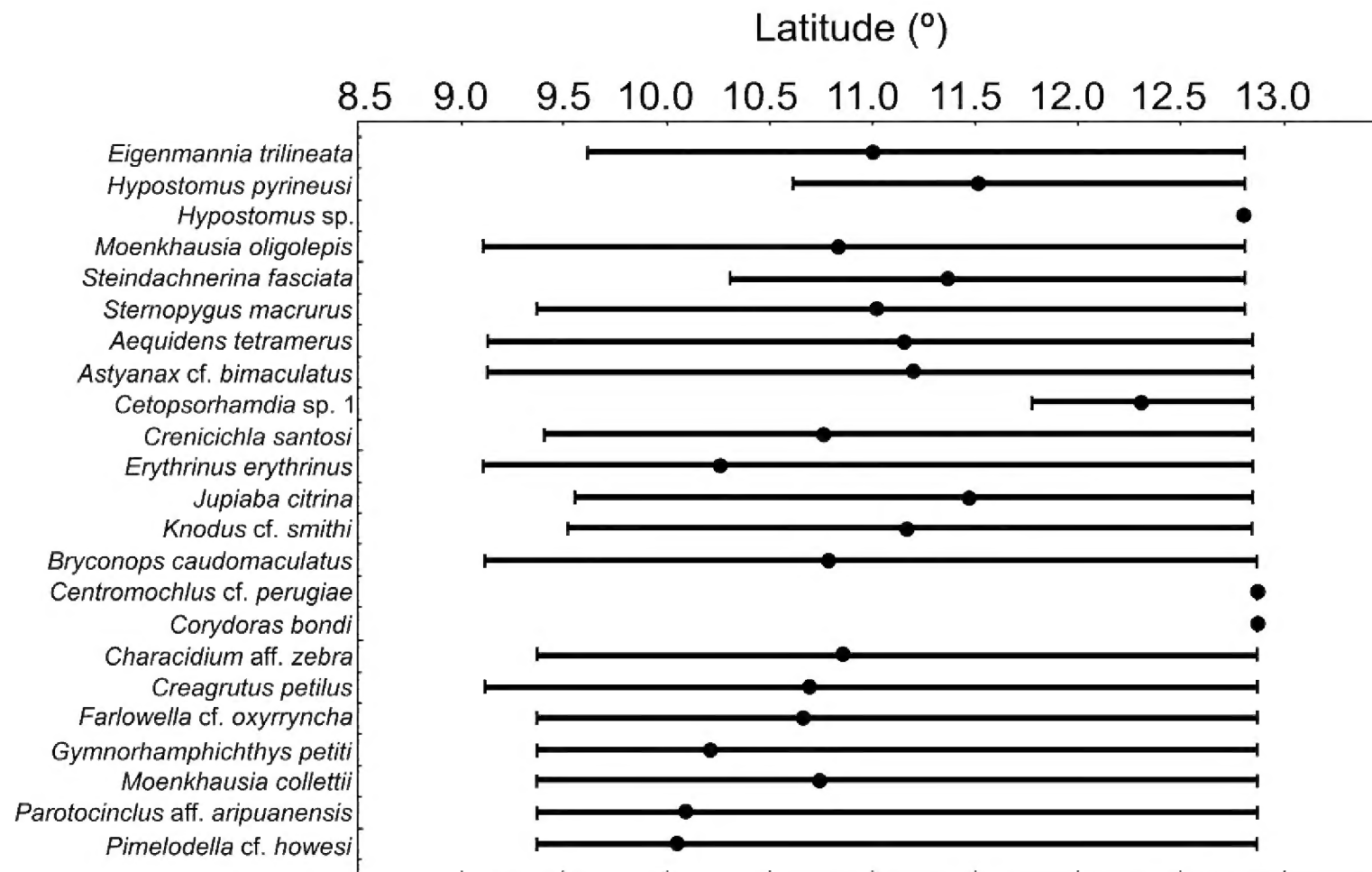


FIGURE 3. CONTINUED.

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